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Work Plan Addendum for Other Area 12 Interim Measure, 2-60s Area

Boeing Plant 2
Seattle/Tukwila, Washington

Prepared For:

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ACRONYMS

bgs	below ground surface
EPA	United States Environmental Protection Agency
EPI	Environmental Partners, Incorporated
ERD	enhanced reductive dechlorination
IM	Interim Measure
mg/L	milligrams per liter
TOC	total organic carbon
VOC	volatile organic compound

1.0 INTRODUCTION

This Work Plan Addendum for the Other Area 12 (OA-12) Interim Measure (IM) has been prepared on behalf of The Boeing Company (Boeing) to facilitate continued groundwater remediation activities at Boeing's Plant 2 in Seattle/Tukwila Washington. This IM Work Plan Addendum has been prepared under the Administrative Order on Consent, dated January 18, 1994, between Boeing and the Environmental Protection Agency (EPA) Region X.

This Addendum has been prepared to describe the process for the next nutrient substrate injection specific to the pilot-scale IM being performed on a portion of the chlorinated volatile organic compound (VOC) OA-12 Plume present in groundwater in the 2-60s Area of Plant 2. The additional nutrient substrate is necessary to continue the enhanced reductive dechlorination (ERD) process, which was selected as a pilot IM remedial technology for the OA-12 VOC plume. A more detailed discussion of the ERD technology was presented in the EPA-approved IM Work Plan for OA-12 Plume (Environmental Partners, Inc. [EPI], 2007). The most recent report on OA-12 provides pilot performance data and the rationale for this second nutrient substrate injection (EPI, 2010).

2.0 BACKGROUND

Plant 2 is located between the Duwamish Waterway and East Marginal Way South in Seattle/Tukwila, Washington. The general location of Plant 2 is shown on Figure 1. Figure 2 presents a representation of the general site features, current structures on the property, and approximate OA-12 IM location at Plant 2.

EPA approved the OA-12 IM Work Plan on February 19, 2008. In late May 2008, six injection wells and three monitoring wells were installed in the A and B levels of the aquifer. These wells, in combination with four existing wells, were used to implement the OA-12 IM. Figure 3 presents the locations of the OA-12 IM wells. OA-12 IM baseline sampling was conducted in early June 2008. Sampling and analytical methods and procedures are specified in the original OA-12 IM Work Plan (EPI, 2007) and are not modified by this addendum.

In mid-July and early August 2008, a carbohydrate solution of reclaimed waste soda, juice, and wine was injected into wells OA12-01A, OA12-01B, OA12-02A, OA12-02B, OA12-03A, and OA12-03B to initiate the ERD process. Approximately 36,000 gallons of nutrient substrate was injected: approximately 14,500 pounds of sugar was injected into the A Level and about 5,600 pounds of sugar was injected into the B Level. The nutrient substrate injection was performed to promote microbiological activity, which consumes oxygen and causes the treated portions of the aquifer to become anaerobic. Anaerobic geochemical conditions in the aquifer favors specific bacteria that have the ability to destroy chlorinated VOCs through reductive dechlorination.

Field parameter measurements made during the first two rounds of post-injection sampling events indicated low pH values as low as 0.89 in a sample from A Level injection well OA-12-02A and 1.98 in a sample from B Level injection well OA12-03B. In response, EPI implemented a

regular program of pH monitoring and buffer solution addition to adjust pH and maintain a neutral pH between 5 and 9, which is optimal for bacterial population growth. Sodium bicarbonate solution was injected to buffer pH levels at wells with pH measurements less than 5. Low pH has been reported at some ERD remediation sites and has been attributed to the microbiological processes induced by the nutrient substrate injection. For the OA-12 IM, EPI believes that a primary cause of low pH was initial acidity of the injected nutrient substrate combined with the formation of carbonic acid and organic acids from nutrient fermentation. The temporary low pH measurements remained localized in the vicinity of the injection wells and low pH was not measured in any of the downgradient wells sampled.

OA-12 IM implementation and performance monitoring results have been reported in a series of three semiannual reports (EPI, 2009a; EPI, 2009b; EPI, 2010). Performance monitoring data indicate that nutrient solution injection has created favorable anaerobic geochemical conditions in the aquifer at the OA-12 IM; however, significant decreases in total chlorinated VOC concentrations have not been noted or maintained for reasons described in EPI, 2010. Accordingly, further contaminant reduction will require an additional nutrient injection to maintain and enhance favorable geochemical conditions for continued reductive dechlorination in groundwater at OA-12.

3.0 NUTRIENT SUBSTRATE INJECTION

A second nutrient substrate injection is proposed for the OA-12 IM pilot. The second injection will differ from the initial injection in several ways described in the sections below.

3.1 Injection Well Redevelopment

Injection wells OA12-01A, OA12-01B, OA12-02A, OA12-02B, OA12-03A, and OA12-03B will be redeveloped by surging and pumping prior to the second nutrient substrate injection. The initial nutrient substrate was a reclaimed material that contained pulp and other particulate matter. Although this reclaimed nutrient substrate was filtered before injection, sampling personnel have indicated that particulate matter and turbid conditions have made performance monitoring sample collection difficult. Additionally, the analytical laboratory has reported matrix interference problems during early sampling rounds that increased detection levels. Redevelopment of the injection wells will remove undesirable matter from the well screen and sand pack to increase the efficiency of nutrient substrate injection and produce less turbid groundwater samples during subsequent monitoring events.

3.2 Nutrient Substrate

A nutrient solution of sugar, sodium bicarbonate, and in potable water will be used as the nutrient substrate material rather than the reclaimed beverage substrate that was used for the initial nutrient substrate injection. The nutrient substrate solution will be made by dissolving food-grade granulated sugar and sodium bicarbonate in potable water in on site mixing tanks and injecting the solution into the A and B level injection wells by gravity or pumping. The target sugar concentration in the nutrient substrate is approximately 6% and will be measured in the field using

a brix meter or equivalent. The sodium bicarbonate buffer concentration will be approximately 1,200 mg/L, which is based on concentration calculations.

Injection of a sugar water nutrient substrate solution will lessen or eliminate many of the problems that were experienced with the initial injection of a reclaimed beverage solution. The problems that will be lessened or eliminated by injecting a sugar water nutrient substrate solution are summarized in the following bullets:

- By mixing the solution to specification a consistent nutrient substrate sugar concentration will be obtained. The reclaimed beverage solution used for the initial injection varied in sugar content from 3.5 to 10.5 percent.

- The mixed sugar water solution will have neutral pH. The reclaimed beverage solution used for the first injection contained carbonated and citric beverages and likely had low pH when it was injected.

- The sugar water solution will be free of particulate matter and color. No filtering will be required prior to injection, as was necessary with the reclaimed beverage solution.

- Sodium bicarbonate buffer will be dissolved and injected with each batch of sugar water nutrient substrate to provide pH buffering throughout the injected volume of substrate solution. This buffering step could not be used for the reclaimed beverage solution because the reclaimed beverage solution reacts and foams when sodium bicarbonate is added.

3.2 Injection

Approximately 21,000 gallons of nutrient solution (produced from approximately 11,200 pounds of sugar) will be injected into the OA-12 IM injection wells. Less sugar will be used than in the original injection because subsurface anaerobic conditions only need to be maintained, rather than converted from an aerobic to anaerobic state and because TOC results indicate that some sugar from the original injection is still present in the aquifer. The same target subsurface sugar concentration of 1,000 milligrams per liter (mg/L) throughout the plume will be used as in the initial injection. The injection design calculations are presented in Table 1. As was done for the initial injection, a greater volume of nutrient solution will be injected into the A Level injection wells (approximately 14,700 gallons) compared to B Level wells (approximately 6,300 gallons). The A Level is naturally geochemically more aerobic than the B Level of the aquifer (due to its contact with vadose zone air) and thus requires more nutrient substrate to maintain the anaerobic geochemical conditions favorable for ERD. Performance monitoring data following the initial injection indicate that this injection strategy was appropriate.

Approximately 210 pounds of sodium bicarbonate buffer at a target concentration of 1,200 mg/L will be dissolved into and injected along with the nutrient substrate solution to maintain optimal pH conditions. This is approximately equal to 1 pound of sodium bicarbonate per 100 gallons of nutrient substrate solution.

4.0 REPORTING, AGENCY INVOLVEMENT, AND SCHEDULE

The proposed second nutrient substrate injection would be performed in May or June 2010 following EPA approval. Documentation of the injection will be provided in the fourth semiannual status report, which would be submitted in September 2010.

5.0 REFERENCES

EPI, 2007 Interim Measure Work Plan for Other Area 12 Plume 2-60s Area. Boeing Plant 2. The Boeing Company, Seattle, Washington. Prepared by Environmental Partners, Incorporated. November 21, 2007.

EPI, 2009a Other Area 12 Interim Measure – First Semiannual Report (revised). Boeing Plant 2. The Boeing Company, Seattle, Washington. Prepared by Environmental Partners, Incorporated. October 12, 2009.

EPI, 2009b Other Area 12 Enhanced Reductive Dechlorination Interim Measure – Second Semiannual Report (revised). Boeing Plant 2. The Boeing Company, Seattle, Washington. Prepared by Environmental Partners, Incorporated. October 12, 2009.

EPI, 2010 Other Area 12 Enhanced Reductive Dechlorination Interim Measure – Third Semiannual Report. Boeing Plant 2. The Boeing Company, Seattle, Washington. Prepared by Environmental Partners, Incorporated. March 1, 2010.

TABLE

Table 1. OA-12 IM Nutrient Substrate Injection Volume Estimate

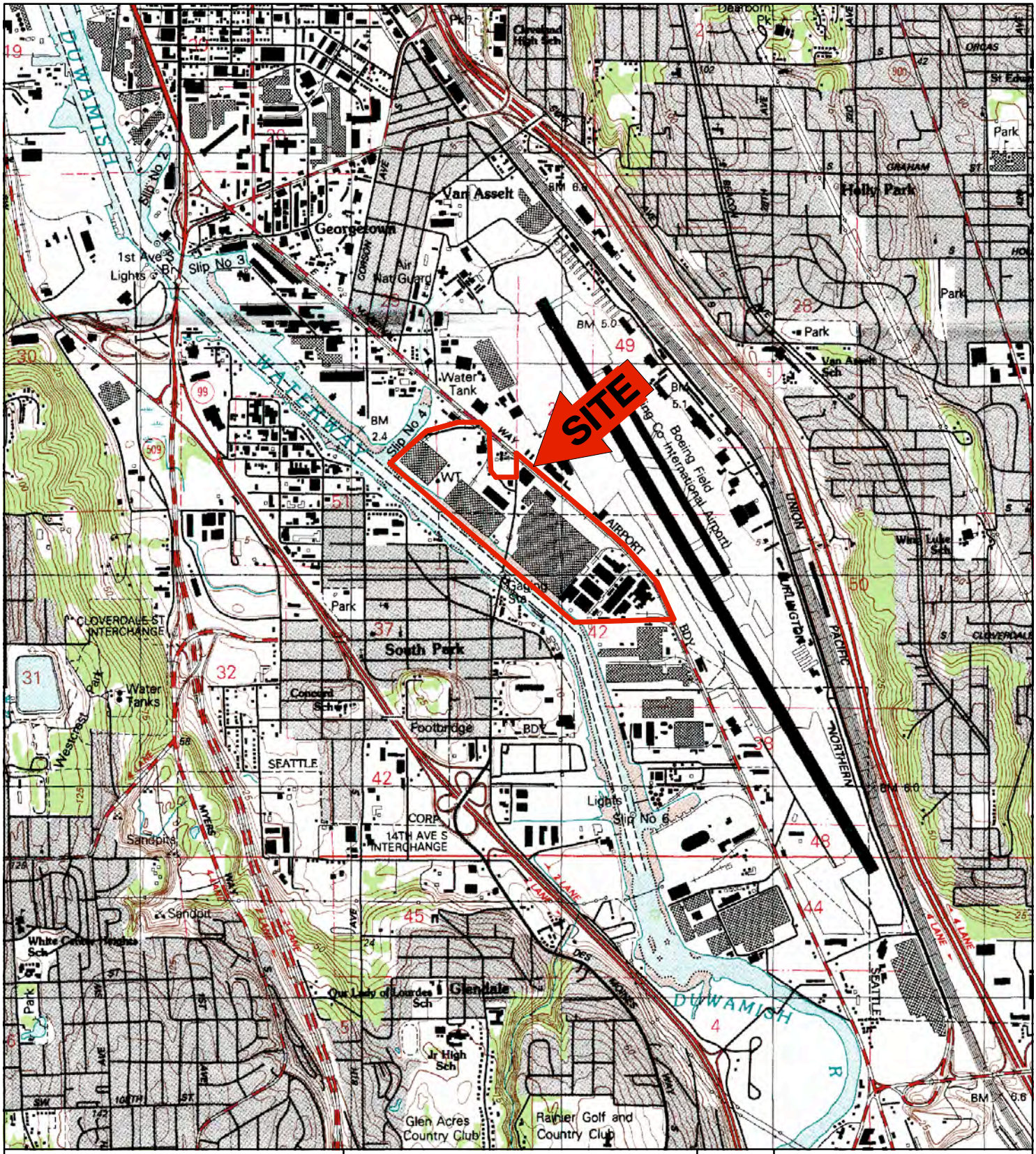
Notes:

1. Pilot Test Area is 150 feet wide (3 wells at 25 feet ROI) and 100 feet long.
2. A Level treated depth is 10 to 30 feet bgs, B Level treated depth is 30 to 50 feet bgs for a total treated depth of 40 feet.
3. Treatment is biased to more aerobic A level.

		Pilot Test Area		
Parameter	Units	Total	A Level	B Level
Treatment Area	ft^2	15,000	15,000	15,000
Depth Interval	ft	40	20	20
Treatment Volume	ft^3	6.00E+05	3.00E+05	3.00E+05
Soil Bulk Density	lbs/ft^3	110	110	110
Soil Mass	lbs	6.60E+07	3.30E+07	3.30E+07
Porosity	ft^3/ft^3	0.3	0.3	0.3
Plume Water Volume	ft^3	1.80E+05	9.00E+04	9.00E+04
Plume Water Volume	gal	1.35E+06	6.73E+05	6.73E+05
Water Density	lbs/ft^3	62.4	62.4	62.4
Plume Water Mass	lbs	1.12E+07	5.62E+06	5.62E+06
Nutrient Substrate Target	ppm	1,000	1,400	600
Nutrient Substrate Mass	lbs	11,232	7,862	3,370
Nutrient Substrate Concentration	%	6	6	6
Specific Gravity	-	1.04	1.04	1.04
Nutrient Substrate Density	lbs/ft^3	64.90	64.90	64.90
Nutrient Substrate Density	lbs/gal	8.68	8.68	8.68
Injected Water Volume	lbs	1.76E+05	1.23E+05	5.28E+04
Injected Water Volume	gal	21,125	14,787	6,337
Injected Volume/Plume Volume	-	0.0157	0.0220	0.0094

(nutrient substrate target concentration, specific gravity, and density for a 6% sugar solution taken from PPC EMF Plume Work Plan)

FIGURES



KEY:

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SOURCE: USGS 7.5 MINUTE QUANDRANGLE (TOPOGRAPHIC)

SEATTLE SOUTH
1983

SCALE = 1:25,000

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FIGURE 1

BOEING PLANT 2
GENERAL LOCATION

PROJECT	OA-12 IM SEMIANNUAL REPORT
PREPARED FOR	THE BOEING COMPANY
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON

SHEET	***DRAWN BY***	***REVIEWED BY***	***DATE***
1 of 1	*ARM*	*JLD*	*02/02/10*

KEY:

APPROXIMATE OA-12 PILOT TEST LOCATION

PLANT 2 BOUNDARY

0 100 200 400

APPROXIMATE SCALE: 1" = 400'

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FIGURE 2

SITE REPRESENTATION

PROJECT	OA-12 IM SEMIANNUAL REPORT		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY ARM	REVIEWED BY JLD	DATE 02/02/10

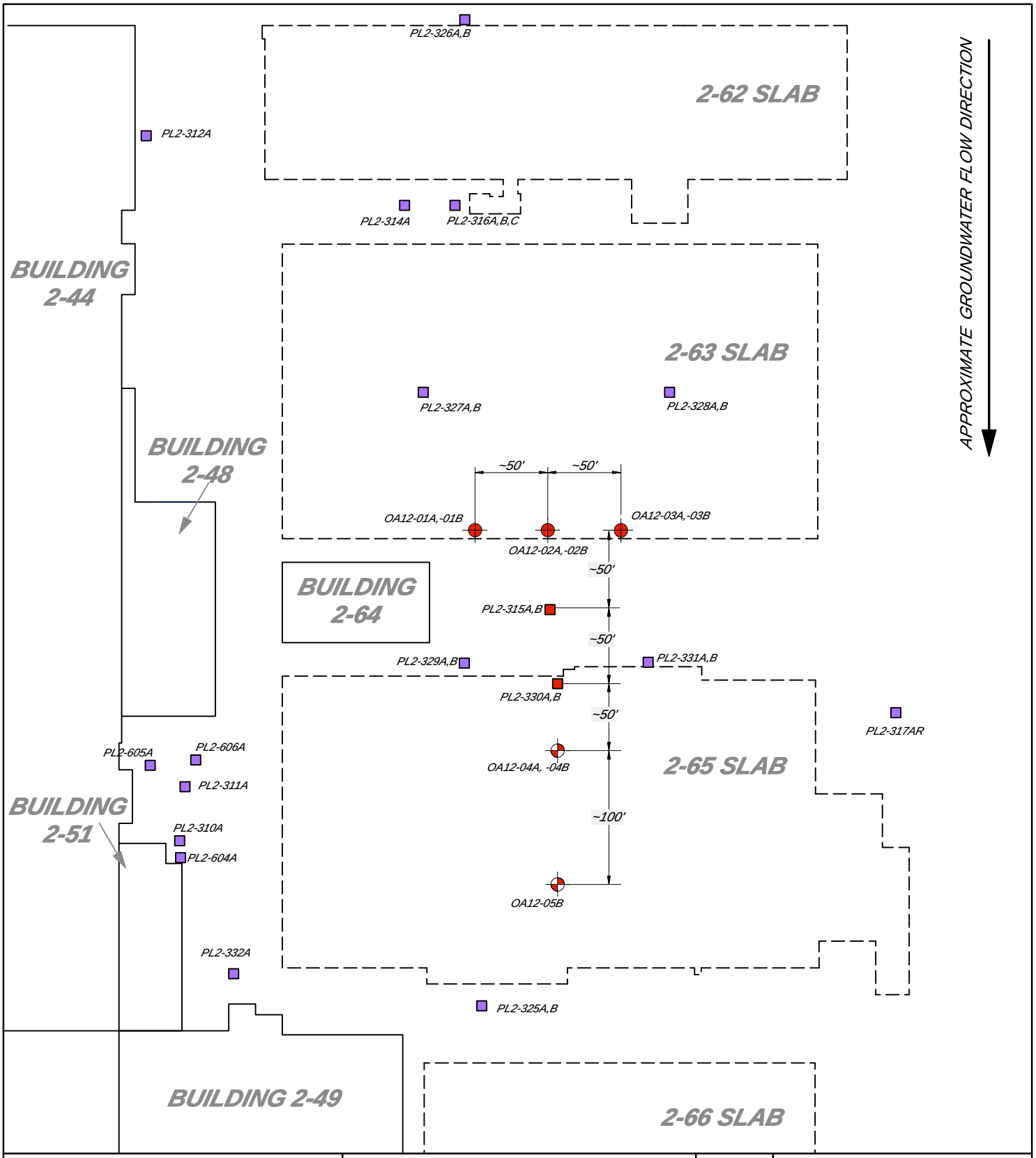

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FIGURE 3

OA-12 INTERIM MEASURES
INJECTION AND MONITORING WELLS

PROJECT	OA-12 IM SEMIANNUAL REPORT		
PREPARED FOR	THE BOEING COMPANY		
LOCATION	BOEING PLANT 2 SEATTLE/TUKWILA, WASHINGTON		
SHEET 1 of 1	DRAWN BY ARM	REVIEWED BY JLD	DATE 02/02/10